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Fluctuations in Agricultural Production: A Comparative Study across Selected Countries

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ABSTRACT

Fluctuation in agriculture is a matter of concern in the recent year. The present study analyses the cross-country fluctuations in agricultural production and the factors affecting the fluctuation in agricultural production. The study aims at studying the fluctuations of crop production, fertiliser consumption, arable land, land under cereal production, and agricultural machinery at the global level. The present study used the Cuddy Della Valle Index and a multiple regression model to analyse the fluctuations in agricultural production across countries. The entire study is divided into four sub-periods: 1981–1990, 1991–2000, 2001–2010, and 2011–2020. Several fluctuations in crop production, fertiliser consumption, arable land, land under cereal production, and agricultural machinery were observed in the study over the period. Different levels of instability were observed over the period of time.

Keywords: Agriculture, Productivity fluctuation, Cross country analysis

JEL Classification Codes: Q1

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I. INTRODUCTION

In the present scenario fluctuations in agricultural production is an essential characteristic of agriculture. In wake of agricultural advancement and the growing need for adoption of high-cost yield-enhancing technology, fertilizers, and vagarious weather are crucial factors that affect fluctuation in agricultural production.

Variation in inputs, technology, and climatic condition are the major causes of fluctuation in agricultural production. In the poor and under developed economics fluctuation in agricultural production is more severe. Agriculture being the largest employer in the major countries, it is necessary to understand the pattern of

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fluctuation (instability) across different countries**.** By use of sustainable practices agricultural production can be increased which is an important way to decrease the amount of land needed for farming and reduces environmental degradation. Since the variables affecting instability have evolved through time, it has become necessary to compare and update instability across different technological and political eras. Due to their vastness, regional variations also take on a substantial significance in a country. The pattern of agricultural growth and response to different stimuli have varied across countries due to variations in climatic conditions, natural resource endowments, institutions, infrastructural developments, population density, etc. The statistics at the world level demonstrate that instability has been a significant in the Fertiliser consumption (kilograms per hectare of arable land), Land under cereal production (hectares), Arable land (% land area), Crop Production and Agricultural machinery (tractors per 100 sq.km of arable land) across countries.

II. REVIEW OF LITERATURE

The contemporary literature is quite diverse in terms of its opinion on fluctuations in agricultural practices. Many suggest that variation in the agronomic practices, irrigation, improved seeds, agro-chemicals, are main causes of fluctuation in agricultural production (Rao, 1968; Das 1978; Ray, 1981; Parthasarathy, 1984; Mitra, 1990; Tewari et al., 2017). On the other hand, authors like Ray (1983), Parthasarathy (1984), and Mitra (1990) indicate that the new farm technology has added to variability in production, while Chand and Raju (2009) and Mahendradev (1987) propose that the same variables lead to a decline in production variability. Increase in the proportion of area under irrigation by tanks and rain fed wells tend to increase production instability (Rao, 1968; Ray, 1981).The nature of crop production technology and availability of material inputs are also found to be responsible for the magnitude of fluctuation in agricultural production (Kaushik, 1993; Sahoo, 2005-06).

Wasim (1999) founded that changes in technology involving the use of high yield variety (HYV) of seeds, fertilizer, and irrigation instruments decreases instability in agricultural production. On the hand Mitra (1990), Parthasarathy (1984), and Ray, (1981) argue that the adoption of new technology and irrigation development are main causes of widespread growth and instability in agricultural production. Instability increases with an increased period of high growth rate in agricultural production. Relationship between growth and instability revealed that there is no basis to believe the hypothesis of high growth causing high instability, (Mahendradev, 1987). Instability has increased in the period characterised by relatively high growth rate in the context of technological change and irrigation development (Mitra, 1990).

Changes in climatic factors like frequent drought, increased rainfall variability and temperature have strong adverse impacts on variability agricultural production (Rao, 1968; Nadkarni & Deshpande, 1982; Parthasarathy, 1984; Kaushik, 1993; Iqbal & Siddique, 2015; Patnaik & Shah, 2015; Senapati and Goyari, 2019). Yield and returns in agricultural production varied with variation in the use of inputs like climatic changes, poor rainfall (Pathiban et al, 2019). Fluctuations in minimum and maximum temperature are found to have a negative impact on production (Iqbal & Siddique, 2015). The amplitude of fluctuations in crop output

tends to rise with the growth as in a year of good rainfall and the soil-moisture is adequate (Rao, 1968; Senapati & Goyari, 2019).

The available literature, however, is largely context specific. While they provide important contextual factors responsible for fluctuations in agricultural productivity, there is a scarcity of literature explaining such factors across different country groups. The present study seeks to bridge this gap by making a cross country analysis of fluctuations in agricultural productivity.

III. METHODOLOGY

Objectives

The broad objectives of the present study are as follows:

- To study the cross country fluctuation in agricultural production
- To identify the factors determining fluctuation in agricultural production

Data Sources

The fluctuation in agricultural production analysis was carried out at world level. The required secondary data was compiled from World Development Indicator (WDI) published by World Bank from 1950 to 2020 Present study will take 35 selected countries' sample size out of 193 member countries of the United Nation. The countries were divided into three groups i.e. high, middle and low income groups, the selection of countries based on World Bank income levels classifications.

Sample of the Study

Data for the present study was collected for the period 1981 to 2020 which was further divided into three sub-periods I(1980-81 to 1989-90), sub-period II (1990-91 to 1999-2000), Sub-period III (2000-01 to 2009-10), sub-period IV (2010-11 to 2011-12).

High income countries (10): United States of America, Japan, Germany, France, UK, Canada, Spain, Saudi Arabia, Italy, and Australia.

Middle income countries (15): China, India, Russia, Indonesia, Brazil, Turkey, Mexico, Egypt, Thailand, Argentina, Pakistan, Nigeria, South Africa, Vietnam, and Kazakhstan.

Low income countries (10): Ethiopia, Nigeria, Bangladesh, Congo, Afghanistan, Burkina Faso, Mali, Madagascar, Mozambique, Guinea**.**

Methods

Multiple Regression model and Cuddy Della Valley index were used to measure sensitivity in agricultural production across selected countries

The present study applies the Cuddy Della Valle Index for measuring the instability. The Cuddy-Della Valle indicator clearly identifies the instability by first de-trending the given series. Time series data with a trend may cause the variation evaluated by CV to be overstated; for example, if CV is used to quantify production instability, a region with consistent production increase may score high, so CDVI is a more accurate indicator of agricultural production instability. Low values of this indicator represent low levels of output instability in

agriculture and vice versa. Thus it is a better measure to capture instability in agricultural production.

CDVI was originally developed by Cuddy and Valle, (1978) for measuring the instability in time series data that is characterized by trend. The estimable form of the equation is as follows:

$$\text{CDVI}=\text{CV}*\sqrt{1-\overline{R^2}}$$

Where CV is the coefficient of variation in percent, and is the coefficient of determination from time trend regression adjusted by the number of degree of freedom.

Multiple regression model is used to describe the factors determining fluctuation in agricultural production. For the estimation of factors affecting fluctuation in agricultural production we have used coefficient of variation of all the variables to find out the variation in the agricultural production, then we have applied the multiple regression model.

$$\text{CP} = f(AM, AL, FC)$$

$$\text{CP} = \alpha+\beta_1\,\text{AM}+\beta_3\,\text{AL}+\beta_4\,\text{FC}+\text{U}$$

Where;

CP= Crop Production

AM=Agricultural machinery, tractors per 100 sq.km of arable land

AL= Arable land (% land area)

FC= Fertiliser consumption (kilograms per hectare of arable land)

U = Error term

Hypothesis of the Study

Null Hypothesis H_0: There has been no variation in instability across countries.

Alternative hypothesis H_1: There are significant variations in instability across countries.

Sub-Hypotheses

The study would test the following null sub-hypotheses against their alternative:

H_{01}: There has been no instability in the low income countries of major variables over the years.

H_{02}: There has been no instability in the middle income countries of major variables over the years.

H_{03}: There has been no instability in the high income countries of major variables over the years.

H_{04}: There is no instability in crop production of low, middle and high income countries.

H_{05}: There is no instability in agricultural machinery of low, middle and high income countries.

H_{06}: There is no instability in land under cereal production of low, middle and high income countries.

H_{07}: There is no instability in arable land of low, middle and high income countries.

H_{08}: There is no instability in fertilizer consumption of low, middle and high income countries

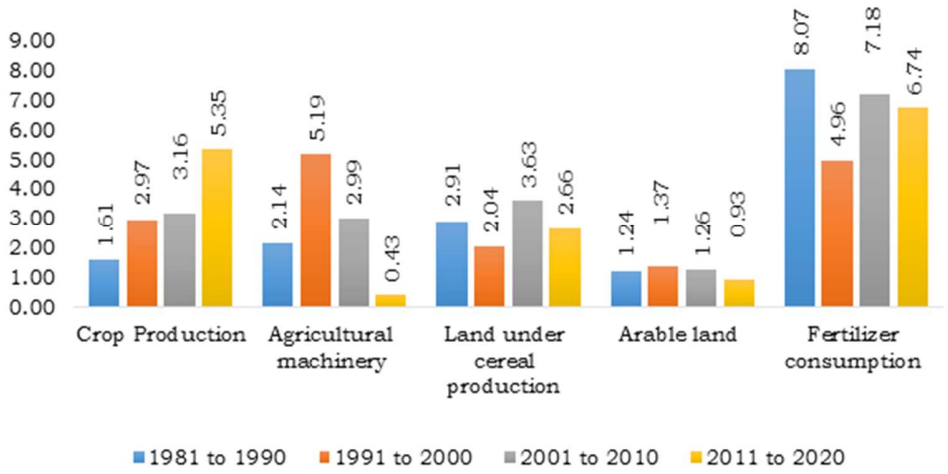
IV. ANALYSIS AND RESULTS

Cross Country Fluctuation in Agricultural Production

Instability of Major Variables for Low-Income Countries

When it comes to the first sub-period's fertiliser consumption, instability is highest in low income countries, and when it comes to arable land, it is lowest. Instability in the second sub-period is highest for agricultural machinery and lowest for arable land. In the third sub-period, arable land has the lowest instability and fertiliser consumption has the highest instability among the major variables. In the fourth sub-period, while agricultural machinery has the lowest. The findings show that in the case of crop production, fluctuation increases throughout the entire sub-period, whereas in the case of arable land, fluctuation is less significant throughout the entire sub-period. In the second sub-period, crop production, agricultural machinery, and arable land volatility increase as compared to the first sub-period, and fertiliser consumption and land under cereal production decrease as compared to the first sub-period. In the third sub-period of crop production, land under cereal production and fertiliser consumption increase, while arable land and agricultural machinery decrease.

Figure-1: Instability of Low Income Countries of Major Variables



Sources-Author's calculation from used WDI dataset

With the exception of crop production, all variables experience less instability in the fourth sub-period compared to the third sub-period. Instability in low-income countries for the major variable of crop production increases throughout the

period by 1.61, 2.97, 3.16, and 5.35 in the sub-periods I, II, III, and IV, respectively. In case of agricultural machinery instability increases in first two decades (I, II) but it is decreasing in third and fourth decades. For land under cereal production in case of low income countries, instability in the first sub-period is higher at 2.91 than instability in second sub-period (1991 to 2000) decreases and the second period is also the lowest instability (2.04) among all the sub-period. But in the third sub-period (2001-2010) further its increases which is highest among the all sub-period. However, it continues to rise throughout the third sub-period (2001-2010), which is the greatest during any sub-period. The fourth also sees a decline (2.66).

The variation in arable land in low income nations has been consistently low over the whole sub period, and the variation in recent years has been particularly low. Arable land fluctuates very little compared to other variables in low-income nations, fluctuating 1.24, 1.37, 1.26, and 0.93 in the sub-periods I, II, III, and IV, respectively. Regarding the consumption of fertiliser, it has been found that low-income countries consumption of fertiliser fluctuates throughout all sub periods with a significant level of instability values. Instability in fertiliser consumption levels is 8.07 in the first sub period and 4.96 in the second, third sub-period is 7.18 and fourth sub-period is 6.74.

The study's conclusions indicate that recent years (decades) have seen low levels of instability in agricultural machinery, land under cereal production, and arable land, together with low CDVI values. It may be stated that in low-income nations, variation in crop output and fertiliser consumption is greater than in the other variables because the instability is more severe in the case of crop production and fertiliser consumption.

Instability of Major Variables for Middle-Income Countries

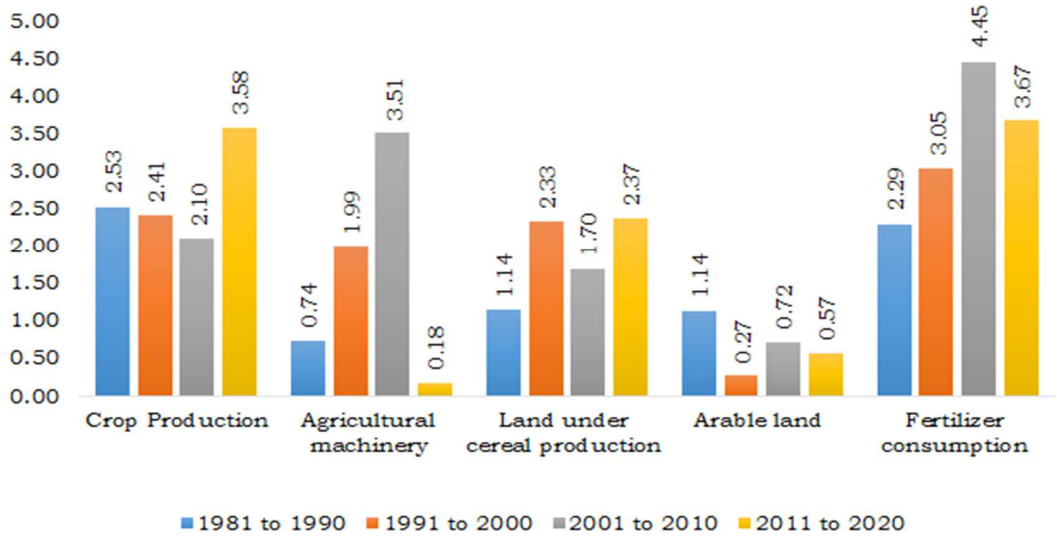
The first sub-period of crop production in middle-income countries is the highest volatile among all variables, with agricultural machinery being the lowest volatile. During the second sub-period, the volatility of fertiliser consumption is highest and lowest in arable land. Fertilizer consumption instability is highest in the third sub-period, and arable land is the lowest of all variables. Fertilizer consumption is the highest volatile in the fourth sub-period, and agricultural machinery is the least stable of all variables. Except for the first sub-period of instability in middle-income countries, fertiliser consumption was the highest across all sub-periods.

Compared to the second sub-period, there is more instability in the first sub-period for crop production and arable land, but less instability for fertiliser consumption, land under cereal production, and agricultural machinery. As compared to the second sub-period, the third sub-period has greater instability in terms of fertiliser consumption, arable land, and agricultural machinery. On the other hand crop production and land under cereal production, however, is less instability.

Crop production fluctuations in middle-income nations show a declining trend in the- I, II, and III sub-periods, but increase in the fourth sub-period. Tractor usage per 100 sq. km of arable land varies in middle-income countries during the course of all three eras, with the exception of the fourth. In middle-income countries, agricultural machinery is unstable at 0.74, 1.99, and 3.51, but in the fourth sub-period, the instability values drop to 0.18, which is a very slight variation

compared to recent decades. It is seen that there is a considerable amount of instability in nations with middle incomes when it comes to land used for growing cereals.

Figure-2: Instability of Middle Income Countries of Major Variables



Sources-Author's calculation from used WDI dataset

In the case of the- I, II, III, and IV sub-periods, the instability (CDVI) values of the land under cereal production are 1.14, 2.33, 1.70, and 2.37. Arable land in the middle-income country shows very little significant change, and the CDVI values for the- I, II, III, and IV sub-periods are 1.14, 0.27, 0.72, and 0.57, respectively.

According to the study's findings, fluctuation in agricultural machinery and arable land is significantly lower in middle-income countries in recent decades (years), whereas fluctuation becomes more severe in crop production, fertiliser consumption, and land under cereal production in recent decades.

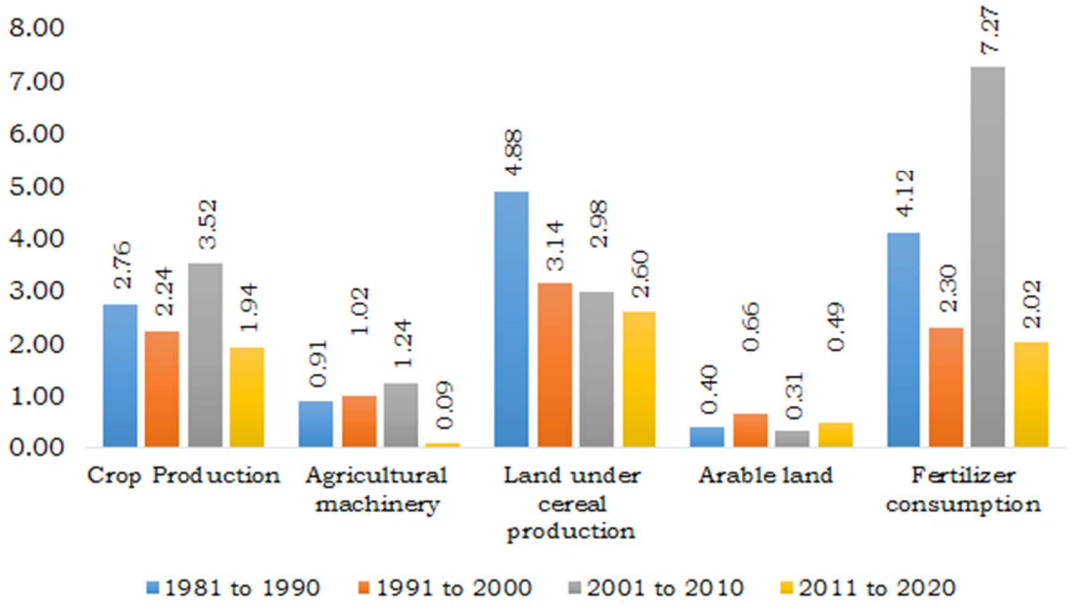
Instability of Major Variables for High-Income Countries

Except for the third sub-period, all of the sub-periods show the highest levels of instability in high income countries in terms of the amount of land under cereal production. On the other hand, the instability of arable land in high income countries is lowest throughout all the sub-periods except the fourth sub-period among all the variables. In the case of fertiliser consumption, instability is highest in the third sub-period among all variables. In the fourth sub-period, instability is lowest in terms of agricultural machinery in high income countries.

The Cuddy Della Valle index values, which are 0.40 in the first sub-period, 0.66 in the second sub-period, 0.31 in the third sub-period, and 0.49 in the fourth sub-period, suggest that there is less significant volatility in arable land. In high income countries, the overall fluctuation is remarkably little. When it comes to crop output, the instability goes down in the second sub-period compared to the

first sub-period, but it goes up in the third sub-period and down in the fourth. From the above table, it can be seen that crop production instability in high income countries has reduced over the past few decades (years).The CDVI (instability) values are 0.91, 1.02, 1.24, and 0.09 in the- I, II, II, and IV sub-periods, respectively. Agricultural machinery instability rises in sub-periods I, II, and III, but it is low in sub-period IV. The study's findings show that recent agricultural machinery instability in high-income nations has been extremely low. In terms of the area used for growing cereals, instability declines over the course of the period, with CDVI values in the first, second, third, and fourth sub-periods being 4.88, 3.14, 2.98, and 2.60, respectively.

Figure-3: Instability in High Income Countries of Major Variables



Sources-Author's calculation from used WDI dataset

The results of the study showed a significant decline in the level of instability in high-income countries. According to the study's findings, variability in agricultural machinery and arable land is significantly lower, and CDVI values are very low, implying that variability in arable land and agricultural machinery is very low in high-income countries. In the case of crop production, land under cereal production, and fertiliser consumption, the fluctuations become moderate.

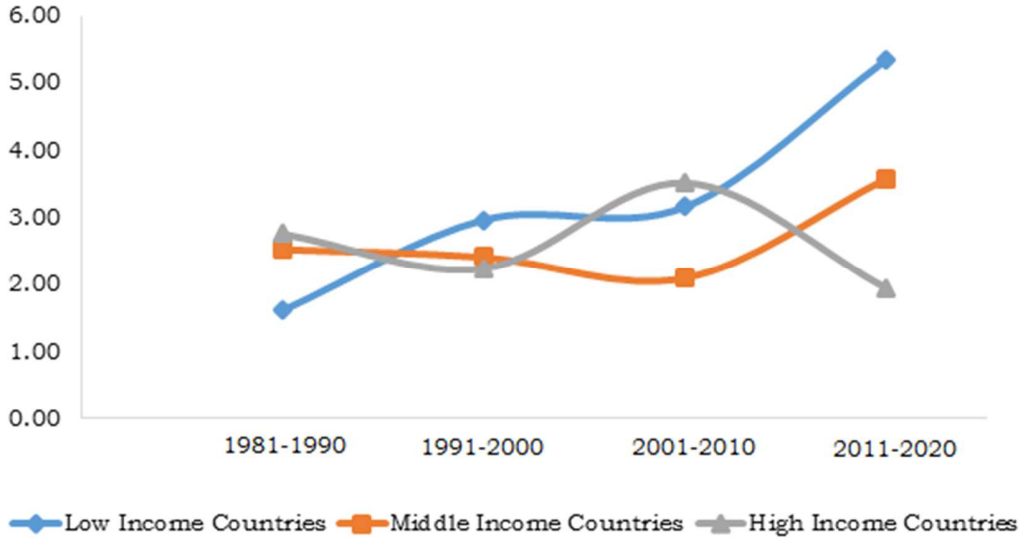
Cross Countries Comparison of the Variables

Instability in Crop Production across Countries Groups

The instability in crop production across countries groups has been studied over four periods: 1981-1990, 1991-2000, 2001-2010 and 2011-2020. Instability in crop production for low income countries increases throughout all the sub-periods. On the other hand, instability in crop production for middle income countries declines in the second and third sub-periods but increases in the fourth

sub-period, and for high income countries, the instability declines in the second sub-period but increases in the third sub-period but declines in the fourth sub-period.

Figure-4: Instability in Crop Production across Countries Groups



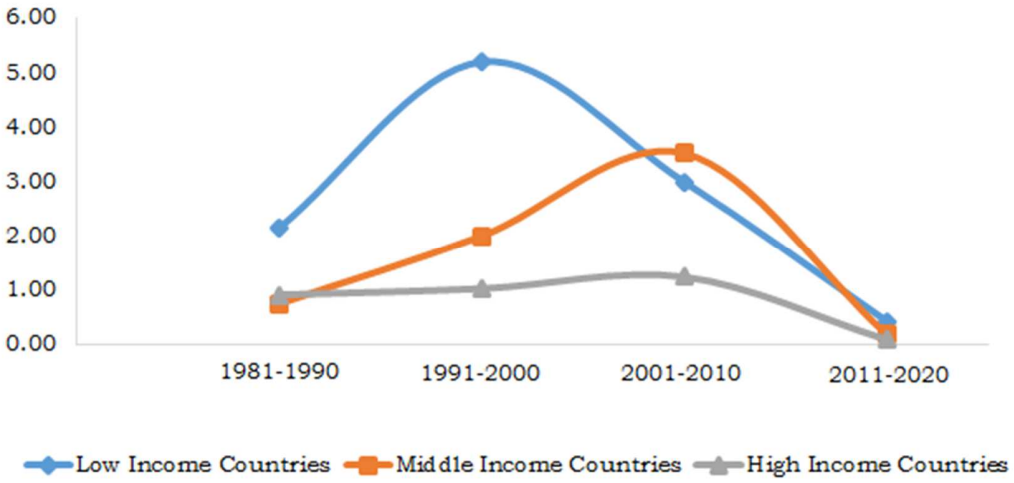
Sources-Author's calculation from used WDI dataset

Crop production instability is highest in high-income countries compared to low and middle-income countries in the first sub-period cross-country comparison. On the other hand, instability is lowest in crop production in low income countries as compared to high- and middle-income countries. It is worth noting that crop production instability is highest in low-income countries compared to high- and middle-income countries in the second sub-period cross-country comparison. On the other hand, instability is lowest in crop production in high income countries as compared to low- and middle income countries. In the third sub-period of the cross-country comparison, high-income countries have the highest level of instability compared to low- and middle-income countries, while middle-income countries have the lowest level of instability compared to high- and low-income countries. In the fourth sub-period, the instability of crop production is highest in low-income countries and lowest in high-income countries. This section examines crop production volatility across country groups (low, middle, and high income countries). According to the study's findings, instability was higher in high-income nations during the first sub period (1981–1991) than in low and middle income countries. On the other hand, instability is high in low-income nations but low in high-income countries during the second sub-period (1991-2000). In contrast to low- and middle-income countries, fluctuations are more pronounced in high-income countries during the third sub-period. Contrary to high- and middle-income countries, crop production has been more unstable over the previous ten years in low-income countries.

Instability in Agricultural Machinery across Countries Groups

Coming to agricultural machinery instability, low-income countries experienced the highest levels of agricultural machinery instability during the first sub-period, whereas middle-income nations experienced the lowest levels. In comparison to the first sub-period, instability rises in all three country groups during the second sub-period. High-income countries have the least instability, whereas low-income ones have the most, according to a cross-country study. The variability of agricultural machinery decreased in the fourth sub-period compared to the third sub-period, with middle-income nations experiencing the largest variability and high-income countries experiencing the lowest. During the fourth sub-period, agricultural machinery variability was highest in low-income countries and lowest in high-income nations. Low-income nations experience more severe agricultural machinery instability in the first sub-period than high-income countries, but average variation becomes mild.

Figure-5: Instability in Agricultural Machinery across Countries Groups



Sources-Author's calculation from used WDI dataset

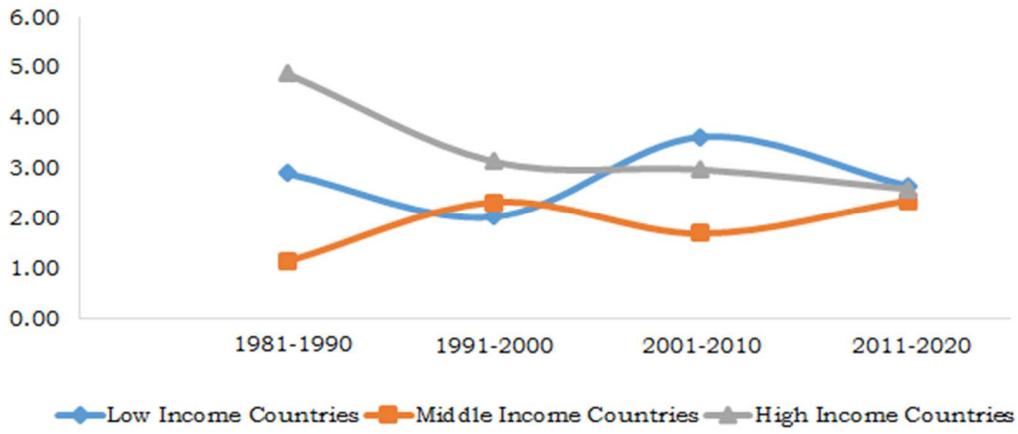
Comparing low-income nations with middle- and high-income countries, the second sub-period agricultural machinery variations in low-income countries are much more severe, and the second sub-period CDVI values in low-income countries are also very high. An interesting fact is, compared to high- and low-income countries, middle-income countries experience more instability during the third sub-period. In recent years, it has been observed that the fluctuation in agricultural machinery across country groups is very low; additionally, CDVI values show the level of instability is very low in recent decades as compared to other decades; thus, the study's findings show that fluctuation becomes very significant and less across country groups in recent years.

Instability in Land under Cereal Production across Countries Groups

Instability in land under cereal production was highest in high-income countries and lowest in middle-income countries during the first sub-period of the cross-

country comparison. In the second sub-period, instability declined in all three nation groups compared to the first sub-period, with the high income countries seeing the highest levels of instability and the low income countries experiencing the lowest levels. The third sub-period in low-income countries has the highest levels of volatility, whereas land used for cereal production has the lowest level in middle-income countries. Comparing the third sub-period to the second sub-period, instability rises in low income countries while falling in middle- and high income countries. In the fourth sub-period, low-income countries experience the most instability, while middle-income countries experience the least, and variability decreases in low- and high-income countries while increasing in middle-income countries.

Figure-6: Instability in land Under Cereal Production across Countries Groups



Sources-Author's calculation from used WDI dataset

In the first sub period, the instability of land used for cereal production becomes more severe in high-income nations, is moderate in low-income countries, and is very low in middle-income countries. In the second sub-period, low-income countries have more severe output fluctuations in terms of the area planted to cereals than high- and middle-income nations. It is also noted that there is a significant level of volatility in middle-income countries during the third sub-period. In the fourth sub-period, instability in cereal production land across countries groups very small and significant fluctuations.

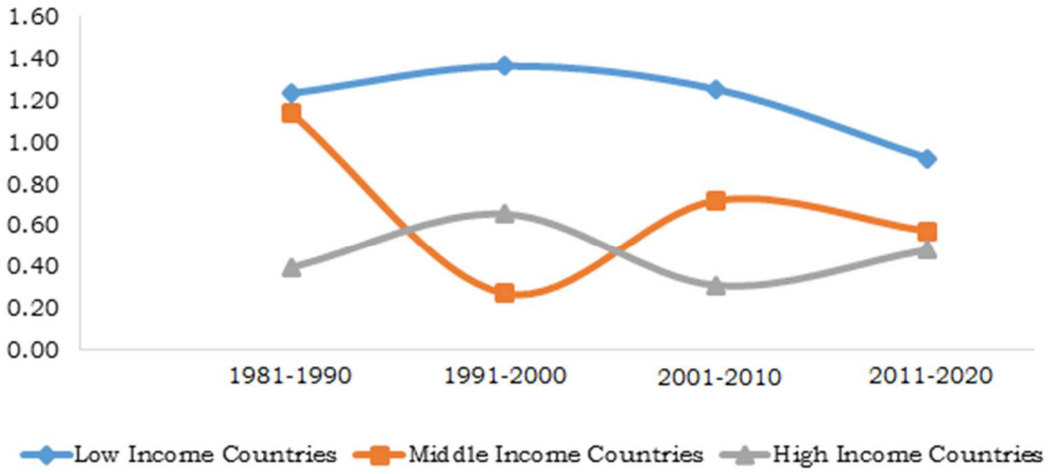
The results of the study demonstrate that there has been less variation in recent years across country groups, and CDVI values indicate that there has been very little major instability in land used for cereal production among country groups in recent decades (years).

Instability in Arable Land across Countries Groups

All of the sub-periods in low income country groups had the highest levels of arable land instability across all country groups. Contrarily, in all sub-periods except the second, there is the least amount of instability in arable land in high-

income countries. The second sub- period lowest level of instability is found in middle-income countries. Arable land variability is larger in low-income nations and lower in high-income countries in the third and fourth sub-periods. The study's findings show that variability in arable land is greater in low-income countries and lower in high-income countries across all time periods.

Figure-7: Instability in Arable Land across Countries Groups



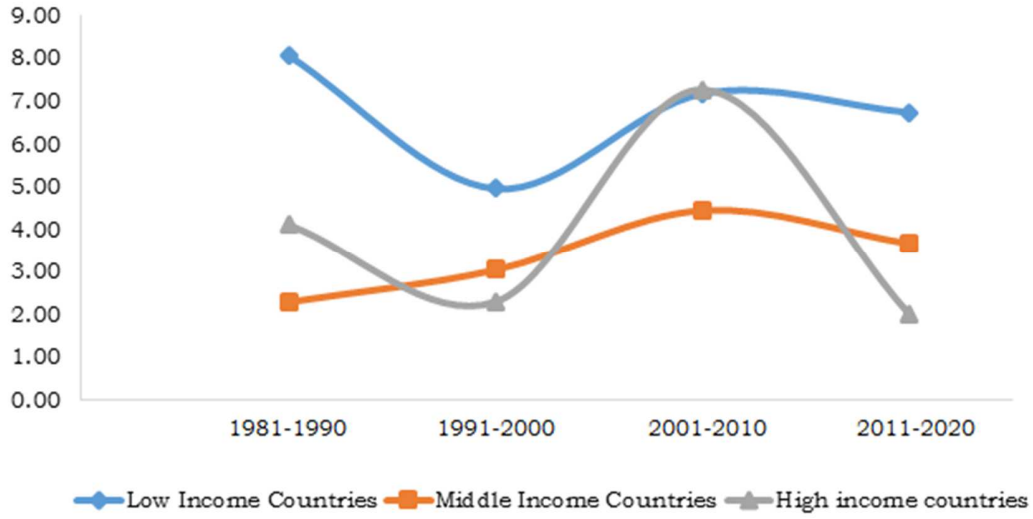
Sources-Author's calculation from used WDI dataset

The study's conclusions include the following: For arable land, instability, or CDVI values are significantly higher in low-income nations throughout all sub-periods than in middle- and high-income countries. The CDVI readings indicate that there is some considerable instability in middle- and high-income countries.

Instability in Fertilizer Consumption across Countries Groups

Instability in fertiliser consumption across country groups in the first sub-period was highest in the low income countries and lowest in the middle income countries. In the second sub-period, low-income countries experience the greatest volatility in fertiliser consumption, while high-income countries experience the least. Finally, in the fourth sub-period of instability, instability is higher in low income nations and lower in high income countries, mirroring the third sub-period of fluctuation's highest fertiliser use in high income countries and lowest in low income countries. Overall, the variability in fertiliser consumption rises during the course of the time. Consumption of fertiliser varies more in low-income countries than it does in middle- and high-income ones.

Figure-8: Instability in Fertilizer Consumption across Countries Groups



Sources-Author's calculation from used WDI dataset

Identifying the Factors Determining Fluctuation in Agricultural Production

High-Income Countries

In terms of factors determining fluctuations in agricultural production in high-income countries, a regression analysis shows arable land (% land area) is significant (at a 5% level of significance), fertiliser consumption (kilograms per hectare of arable land) is significant (at a 1% level of significance), and agricultural machinery (tractors per 100 square kilometres of arable land) is insignificant.

Table-1: Coefficient Table of High Income Countries

Variables	Beta	t values	Significance
Constant		1.912	0.64
Agricultural machinery, tractors per 100 sq.km of arable land	.027	.426	.672
Arable land (% land area)	-.118*	-2.548	.015
Fertiliser Consumption(kilograms per hectare of arable land)	.958**	14.945	.000

Note-**=1% & *= 5% level of significance
R square is .945
Sources-Author's calculation from used WDI dataset

The current analysis's conclusion that crop production fluctuations and agricultural machinery (tractor per 100 square kilometres of arable land) have a positive relationship is supported by the finding that, in high-income countries, an increase in agricultural machinery fluctuations (tractor per 100 square kilometres of arable land) causes an increase in crop production fluctuations of 2.7 percent.

We have discovered a similar negative and substantial link between variance in arable land and crop production in this example. In high-income nations, a rise in the fluctuation of arable land (% land area) causes a drop of 11.85% in the variation of crop production. Thus, variation in arable land (% land area) minimises variation in crop production.

Variation in fertiliser consumption (kilogrammes per hectare of arable land) and crop productivity are significantly and favourably correlated. In high-income countries, changes in fertiliser consumption (kg per hectare of arable land) lead to an increase in crop output fluctuations of 95.8%. Therefore, the main factor influencing changes in crop productivity is fertiliser consumption.

The R square of this model is .945 i.e. the variation in dependent variable is 94.5% explained by variation in independent variables and rest is explained by the error term.

Middle-Income Countries

For middle-income countries, the multiple regression analysis shows that the independent variables agricultural machinery (tractors per 100 sq. km. of arable land), fertiliser consumption (kg per hectare of arable land), and arable land (%) are all significant at the 5% level of significance.

Variation in the use of agricultural machinery (tractors per 100 square kilometres of arable land) leads to a 32.7% decrease in crop production variation in middle-income countries. We discovered a significant and negative relationship between fluctuation in agricultural machinery (tractors per 100 square kilometres of arable land) and crop production.

Table-2: Coefficient Table of Middle Income Countries

Variables	Beta	t values	Significance
Constant		-1.802	.080
Agricultural machinery, tractors per 100 sq.km of arable land	-.327*	-3.119	.004
Arable land (% land area)	.486*	2.978	.005
Fertiliser Consumption(kilograms per hectare of arable land)	.265*	2.255	.030

Note-**=1% & *= 5% level of significance
R squares is .897
Sources-Author's calculation from used WDI dataset

The coefficient table demonstrates the substantial and positive association between crop production and arable land fluctuation, demonstrating that a rise in arable land fluctuation (land area) causes an increase in crop output fluctuation of 48.6%. There is a considerable and favourable correlation between fertiliser consumption (kilogrammes per hectare of arable land) and crop production in middle-income countries. We found that an increase in the volatility of fertiliser use (kg per hectare of arable land) causes an increase in the variation of crop production of 26.5%.

Low-Income Countries

Coming to low-income countries, the variable arable land (% land area) is significant in low-income nations at the 5% level of significance, whereas the other

two variables are not. This is evident from the coefficient table above. A rise in the usage of agricultural machinery (tractors per 100 sq. km. of arable land) causes a rise in the volatility in crop production of 6.3%, which is not significant in low-income countries, according to the coefficient table, which also demonstrates a positive association between the two variables. The coefficient values in low-income nations demonstrate a significant and favourable association between arable land and crop production, with a rise in arable land variation (% of land area) resulting in increases in crop production variation of 6.3%. Additionally, the coefficient table demonstrates that crop production and fertiliser consumption (in kilogrammes per acre of arable land) in low-income nations have a negligible and adverse association. In low-income countries, volatility decreases by 11.1% as fertiliser consumption fluctuates more frequently.

Table-3: Coefficient Table of Low Income Countries

Variables	Beta	t values	Significance
Constant		-2.626	.013
Agricultural machinery, tractors per 100 sq.km of arable land	.063	.820	.417
Arable land (% land area)	.859*	8.867	.000
Fertiliser Consumption(kilograms per hectare of arable land)	-.112	-1.251	.219

Note-**=1% & *= 5% level of significance
R squares is .827
Sources-Author's calculation from used WDI dataset

The above coefficients table shows that out of 3 independent variables, the factor of agricultural machinery in low-income countries is significant at the 1% level of significance. In middle-income countries, all the independent variables are significant at the 5% level of significance. AL has 1% significance in high-income countries, and FC has a 5% significance.

R square defines that, in low, middle, and high income countries, the variation in crop production (dependent variables) is explained by independent variables by 82.7%, 89.7%, and 94.5%, respectively, with the rest by unexplained variables (residuals or error terms).

V. CONCLUSION

The results show that fluctuation (instability) in fertiliser consumption is significantly higher in low-income countries than in middle- and high-income countries due to factors such as fertiliser price, fertiliser subsidies, agricultural credit, and the area under HYVP crops. Because of the low percentage of irrigated area to total crop area, the adoption of new technology, the decline in use of seeds and manure, and other agricultural inputs, crop production variability is more pronounced and increases over time in low-income countries. Instability in land under cereal production in low income countries is more due to variability in climatic factors and policy environments; average cereal production did not register significant change and Lack of infrastructure. Fluctuation in arable land is low in high income countries as compared to low- and middle income countries because, in high income countries, arable land declines over time due to urban development and industrialization. In low income countries, the instability of agricultural machinery is high because of a lack of advanced technology and the

demonstration effect. From multiple regression model observed that there is positive relationship between crop production and Agricultural machinery tractors per 100 square kilometres of arable land in low income countries, the variation (Fluctuation) in crop production increases by 6.3% as the use number of agricultural machinery, tractors per 100 sq. km. of arable land increases. In the middle income countries, there is a negative relationship between the crop production and agricultural Machinery, the variation in the crop production decreases by 32.7% as the number of agricultural machinery tractors per 100 sq. km of arable land increases. There is a positive relationship between crop production and agricultural machinery in high-income countries; the variation in crop production increases by 2.7% as the number of tractors per 100 square kilometres of arable land increases. In the case of arable land, the relationship between crop production and agricultural machinery is positive in low and middle-income countries but negative in high-income countries. The variation in crop production increases by 85.9% and 48.6%, respectively, as the arable land (% land area) increases in low and middle-income countries. But in high-income countries it shows a negative relationship; variation in crop production decreases by 11.8% as the arable land area (% land area) increases. In the case of fertiliser consumption, crop production and fertilizer consumption have positive relationships in middle- and high-income countries but negative ones in low income countries. The variation in crop production increases by 26.5% and 95.8% in middle- and high-income countries, respectively, as the fertilizer consumption kg per hectare of arable land increases. In the case of high-income countries, the variation in crop production decreases by 11.2% as the fertilizer consumption kg per hectare of arable land increases.

VI. REFERENCES

Anjum, S., & Madhulika. (2018). Growth and instability analysis in Indian agriculture. *International Journal of Multidisciplinary Research and Development, 5*(11), 119-125.

Brada, J. C. (1986). The Variability of Crop Production in Private and Socialized Agriculture: Evidence from Eastern Europe. *Journal of Political Economy, 94*(3), 545-563.

Chand, R., & Raju, S. S. (2008). Instability in Andhra Pradesh Agriculture -A Disaggregate Analysis. *Agricultural Economics Research Review, 21*(2), 283-288.

Chand, R., & Raju, S. S. (2009). Instability in Indian Agriculture During Different Phases of Technology and Policy. *Indian Journal of Agricultural Economics, 64*(2), 188-207.

Cuddy, J. D., & Valle, P. D. (1978). Measuring the Instability of Time Series Data. *Oxford Bulletin of Economics and Statistics, 40*(1), 79-85.

Das, P. S. (1978). Growth and Instability in Crop Output in Eastern India. *Economic and Political Weekly, 13*(41), 1741-1748.

Dayal, E. (1984). Agricultural Productivity in India: A spatial Analysis. *Annals of the Association of American Geographers, 74*(1), 98-123.

Hazell, P. B. (1984). Sources of Increased Instability in Indian and U.S. Cereal Production. *American Journal of Agricultural Economics, 66*(3), 302-311.

Iqbal, K., & Siddique, M. A. (2015). The Impact of Climate Change on Agricultural Productivity: Evidence from Penal Data Of Bangladesh. *The Journal of Developing Areas, 49*(6), 89-101.

Joshi, D., & Singh, H. P. (2015). An Emperical Analysis OF Growth and Instability in Major Spices in India. *International Journal of Agriculture Sciences, 7*(2), 440-444.

Kaushik, K. K. (1993). Growth and Instability of Oilseeds Production. *Indian Journal of Agricultural Economics, 48*(3), 334-338.

Larson, D. W., Jones, E., Pannu, R. S., & Sheokand, R. S. (2004). Instability in Indian Agriculture -A challenge to the Green Revolution Technology. *Food Policy, 29*(3), 257-273.

Mahendradev, S. (1987). Growth and Instability in Foodgrains Production: An Inter-State Analysis. *Economic and Political Weekly, 22*(39), A82-A92.

Mehra, S. (1981). *Instability in Indian Agriculture in the Context of New Technology.* Washington, D.C., U.S.A: International Food Policy Research Institute.

Mitra, K. A. (1990). Agricultural Production in Maharashtra: Growth and Instability in the Context of New Technology. *Economic and Political Weekly, 25*(52), A146-164.

Nadkarni, M. V., & Dashpande, R. S. (1982). Agricultural Growth, Instability in Productivity and Rainfall: Case of Karnataka. *Economic and Political Weekly, 17*(52), A127-A134.

Parthasarathy, G. (1984). Growth Rates and Fluctuations of Agricultural Production: A District-Wise Analysis in Andhra Pradesh. *Economic and Political Weekly, 19*(26), A74-A84.

Parthiban, J. J., Rajesh, R., & Shyam, G. S. (2019). Trend Analysis of Area, Production and Productivity of Groundnut and Estimation of Cost of Production in Tiruchirappalli District. *International Journal of Agriculture Sciences, 11*(10), 8488-8490.

Pattnaik, I., & Shah, A. (2015). Trends and Decomposition of Agricultural Growth and Crop Output in Gujarat: Recent Evidence. *Indian Journal of Agricultural Economics, 70*(2), 183-195.

Pratt, A. N., Yu, B., & Fan, S. (2010). Comparisons of agricultural productivity growth in China and India. *Journal of Productivity Analysis, 33*(3), 209-223.

Rao, C. H. (1968). Fluctuations in Agricultural Growth: An Analysis of Unstable Increase in Productivity. *Economic and Political Weekly, 3*(1/2), 87-94.

Ray , S. K. (1981). Weather, Prices and Fluctuations in Agricultural Production. *Indian Economic Review, 16*(4), 251-277.

Ray, S. K. (1983a). An Emperical Investigation of the Nature and Causes for Growth and Instability in Indian Agriculture:1950-80. *Indian Journal of Agricultural Economics, 38*(4), 459-474.

Sahoo, R. L. (2005-2006). Trends in Agricultural Production in Colonial Coastal Orissa, 1912-1942. *Proceedings of the Indian History Congress, 66*(22), 600-614.

Sawant, S. D., & Achuthan, C. V. (1995). Agricultural Growth across Crops and Regions: Emerging Trends and Patterns. *Economic and Political Weekly, 30*(12), A2-A13.

Senapati, A. K., & Goyari, P. (2019). Growth and instability in agricultural productivity in Odisha. *Agricultural Economics Research Review, 32*(1), 55-65.

Sharma, H. R., Singh, K., & Kumari, S. (2006). Extent and Source of Instability in Foodgrains Production in India. *Indian Journal of Agricultural Economics, 61*(4), 1-20.

Swain, M. (2014). Sources of Growth and Instability in Agricultural Production in western Odisha, India. *Asian Journal of Agriculture and Development, 11*(2), 52-70.

Tewari, H., Singh, H. P., & Tripathi, U. (2017). Growth and Instability in Wheat Production: A Region Wise Analysis of Uttar Pradesh, India. *International Journal of Current Microbiology and Applied Sciences, 6*(9), 2537-2544.

Wasim, M. P. (1999). Growth Rates and Fluctuations in Area, Production and Productivity: A Study of Major Crops in Sindh. *Pakistan Economic and Social Review, 37*(2), 155-168.